Weighing Lake Michigan: Lake Michigan Mass Balance
A grant/contract summary document

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Disclaimer

The information in this report is current as of September 1998. Due to the possible changes in information, it is recommended that up-to-date information be obtained from the listed contacts or contact GLNPO.

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Acknowledgments

I would like to thank the numerous GLNPO staff members who filled in the blanks for my summary information and answered the plethora of accompanying questions. The project officer reviews of each draft were particularly helpful. Without the assistance of the grantees and contractors, many unknowns would have remained.

I am grateful to GLNPO for providing me with this wonderful opportunity. I have leaned more in my short stay then I could have imagined; the benefits of experience are immeasurable. My tour of Lake Erie on the R/V Lake Guardian was a wonderful supplement to my experience. Region 5 GLNPO was a very welcoming and enriching atmosphere. Special thanks go to my Project Mentor, Deborah Lamberty, and my Project Director, Paul Horvatin.

ABalance is the perfect state of still water. Let that be our model. It remains quiet within and is not disturbed on the surface.@
-Confucius

Acronyms

BCC- Bioaccumulative Chemicals of Concern
CAAA- Clean Air Act Amendment
DOI-United States Department of the Interior
EC-Environment Canada
EMP-Enhanced Monitoring Program
FY-Fiscal Year
GBMB-Green Bay Mass Balance
GIS-Geographic Information Systems
GLAD-Great Lakes Atmospheric Deposition
GLERL-Great Lakes Environmental Research Laboratory
GLI-Great Lakes Water Quality Initiative
GLMBD-Great Lakes Mass Balance Database
GLNPO-Great Lakes National Program Office
GLWQA-Great Lakes Water Quality Agreement
HAP-Hazardous Air Pollutant
Hg-Mercury
IADN-Integrated Atmospheric Deposition Network
IAG-Interagency agreement
LaMP-Lakewide Management Plan
LMF-Lake Michigan Federation
LMMB-Lake Michigan Mass Balance
MDEQ-Michigan Department of Environmental Quality
MDNR-Michigan Department of Natural Resources
NOAA-National Oceanic and Atmospheric Administration
ORD- Office of Research and Development
OW-Office of Water
PAH-Polynuclear Aromatic Hydrocarbons
PCB-Polychlorinated Biphenyls
PI-Principal Investigator
PO-Project Officer
RDMQ-Research Data Management and Quality Control
R/V Lake Guardian-Research Vessel Lake Guardian
SUNY-State University of New York
QA-Quality Assessment
QC-Quality Control
UMAQL-University of Michigan Air Quality Laboratory
USDOE-United States Department of Energy
USEPA-United States Environmental Protection Agency
USFDA-United States Food and Drug Administration
USFWS-United States Fish and Wildlife Service
WDNR-Wisconsin Department of Natural Resources

Introduction

The Great Lakes system, as the largest supply of freshwater on the Earth, is a vital resource to the US and Canada. However, the Lakes= ecosystem faces continual challenges from contaminated fish and wildlife, diminished wetlands, exotic species, and the depleted native fish population. The 1972 Great Lakes Water Quality Agreement (GLWQA) united the US and Canada in a Great Lakes remediation effort and provided a template for the formation and future goals of the Great Lakes National Program Office (GLNPO) of the United States Environmental Protection Agency (USEPA). GLNPO=s mission is to maintain and restore the chemical, biological, and physical unity of the Great Lakes. Currently the US and Canada are involved with projects assessing contaminated sediments, pollution prevention, habitat protection, exotic species identification, and other emerging issues.

In 1998 the Great Lakes National Program Office (GLNPO) of the USEPA received 230 preproposals from 128 applicants seeking 30.2 million dollars in funding for Great Lakes projects. After the selection process, 59 projects were chosen to receive the available funding, 4.4 million dollars. Each year new grants and contracts are awarded based on GLNPO=s current priorities. An annual AGreat Lakes Priorities and Funding Guidance@ document is published stating GLNPO=s expectations for projects. Federal, state, tribal, local, and industrial partners assist in attaining GLNPO=s goals by involving themselves in these grants, interagency agreements, and contracts. Starting in 1993, a substantial portion of the grant/contract funds was allotted for a Lake Michigan Mass Balance Study(LMMB).

Table 1. Organizations

Organization	Number of Grants
American Mangement Systems, Inc.	**1**
Dyncorp	**1**
Environment Canada	**1**
Illinois Institute of Technology	**1**
Indiana University	**1**
Lake Michigan Federation	**1**
Michigan Department of Environment Quality	**1**
National Oceanic and Atmospheric Administration	**2**
The Research Foundation of State University of New York	**3**
University of Illinois	**2**
University of Maryland, Chesapeake Biologist Laboratory	**1**
University of Michigan	**3**
University of Minnesota	**2**
United States Department of Energy	**2**
United States Fish and Wildlife Service	**3**
United States Geological Survey, Great Lakes Science Center	**2**
Wisconsin Department of Natural Resources	**1**

Table 2. Number of Grants per Fiscal Year

Fiscal Year	Number of New Projects	Number of Continuing Projects
1993	3	0
1994	12	3
1995	5	14
1996	3	16
1997	5	14
1998	N/A	14
1999	N/A	10

Mass Balance

A Mass Balance Study is based on the classical concept of the conservation of mass: the total mass of a system remains unchanged. Mass Balance focuses on the fact that the amount of pollutant entering a system should equal the amount of pollutant leaving, trapped in, or chemically changed in a system. Scientists take many samples in order to track certain substances. They use this data to develop mathematical models hypothesizing relationships between the foreign substances and the environment. Modelers can eventually use their findings to provide a broader knowledge base for future policy-making and environmental management strategies.

Lake Michigan acts as a Apollutant sink@ for toxic substances because it is a fairly enclosed system. Estimates show that a single drop of water could remain in the Lake for more than 100 years before it escapes; sediments= Alife@ in the lake is even longer. Because of this confined system, contaminants from the past and the present cause ecological problems. According to the United States Food and Drug Administration (FDA), many Lake Michigan fish have unsafe levels of the toxins. Contaminated fish were an early indication that the Great Lakes had pollution problems. Although problems were recognized, the information necessary for the evaluation and source determination was not available. The Great Lakes Water Quality Agreement (GLWQA) of 1972 set a precedent for Great Lakes remediation. In an effort to respond to protocols such as the GLWQA and Lakewide Management Plans (LaMPs), the USEPA began mass balance studies. After the reported success of the Green Bay Mass Balance Study(GBMB) from 1988-1992, a larger scale project was launched by GLNPO and Office of Research and Development (ORD) in 1993: Lake Michigan Mass Balance (LMMB.) LMMB is part of the Lake Michigan Enhanced Monitoring Program and builds upon the monitoring, modeling, and technological procedures used in the GBMB study. LMMB specifically targets total mercury, polychlorinated biphenyls, atrazine, and trans-nonachlor encroaching upon Lake Michigan from the atmosphere, lake sediment, and/or tributaries.

Over 200 sampling stations were utilized for the Study in Lake Michigan. From 1994-1995 over 25,000 samples were taken. The Great Lakes National Program Office=s Research Vessel (R/V) Lake Guardian was employed for the project=s open lakes samples. This Vessel tours the Great Lakes year round and is used for many GLNPO projects and selected personal research. Although sampling for the Project is complete, analysis and Quality Assurance (QA) will continue until 1999.

The chief goal of the LMMB study is to gather a well-established set of scientific data in order to direct future toxic reduction endeavors from regulatory agencies for Lake Michigan. The key objectives to accompany this goal are:

- **identifying contaminant loading rates**; this information will be used to estimate future rates coming from the atmosphere, tributaries, and lake sediment.
- **evaluating benefits**; present and future regulatory measures will be assessed.
- **forecasting benefits**; management strategies and a timetable will also be established.
- **understanding ecosystem dynamics;** a more complete knowledge of the path of the contaminants through the closed ecosystem will be obtained.

Contaminants

The Lake Michigan Mass Balance Study follows four toxins in Lake Michigan: polychlorinated biphenyls (PCBs), mercury, trans-nonachlor, and atrazine. These four contaminants were selected in order to receive a representative sampling of Lake Michigan. All of the toxins except atrazine are included in the Great Lakes Water Quality Initiative(GLI) which recognized 29 pollutants as bioaccumulative chemicals of concern(BCCs.) Bioaccumulative refers to a characteristic possessed by some toxins in which they become more concentrated as they ascend the food chain hierarchy. Many of the Great Lakes= fish have dangerous levels of toxin concentrations according to FDA standards; many fishing advisories have been issued for the Great Lakes.

Polychlorinated Biphenyls (PCBs)

PCBs are human-produced industrial chemicals. They are most commonly seen in electrical transformers and capacitors as coolants. PCBs have also been used as heat transfer and hydraulic fluids; as dye carriers in carbonless copy paper; in paints, adhesives and caulking compounds; and as sealants and road coverings to control dust. The production of this substance was halted in the US when the EPA took regulatory measures in May of 1979 banning the manufacture of PCBs. At the same time, EPA began prohibiting certain uses of PCBs.

Potential Harmful effects:

- $ possible human carcinogen
- $ stomach, liver, and kidney damage
- $ skin irritation
- $ thyroid gland problems

Although PCBs are currently regulated, they still exist in the environment at sites where previous spills have not been cleaned up properly or in contaminated lake sediment where they remain a threat to the environment and its inhabitants. Humans can be exposed to the chemicals by eating contaminated fish or shellfish.

Mercury(Hg)

Mercury is a naturally occurring toxic element. The release of mercury can be from natural processes or initiated by human activity. Combustion of certain fuels and incineration of mercury-containing wastes (i.e., battery cells, barometers, thermometers, and switches)

Potential Harmful effects:

- $ possible human carcinogen
- $ stomach, large intestine, brain, lung, and kidney damage
- $ blood pressure and heart rate increase
- $ fetus damage

Chemical spills and the incineration of Hg containing substances threaten the environment. Mercury does not metabolize easily, in fact, it is stored for long periods of time in fat tissue. The bioaccumulative characteristic means that minute amounts of mercury in the environment can cause significant levels of mercury in fish, wildlife, and humans.

Trans-Nonachlor

Trans-Nonachlor is one of the constituents of the now canceled insecticide chlordane. Chlordane was primarily used as a pesticide between 1948 and 1988. Most of the chemical=s uses were canceled in 1978; termite control, the remaining use, was finally canceled in 1987. Manufacture of chlordane continued in the U.S. to supply the export market until 1997, when production was terminated, and remaining stocks shipped.

Potential Harmful effects:

- **$** human carcinogen (classification B2, probable human carcinogen)
- **$** neurological effects from prolonged oral, inhalation or dermal exposure
- **$** blood dyscrasia, hepatoxicity, and immunotoxicity
- **$** endocrine system problems

Trans-Nonachlor is bioaccumulative, as are most of the components of commercial chlordane, and is very persistent in soil, aquatic media, and in the absorbed state of living organisms. Distribution in the environment can occur through soil run-off and atmospheric transport, leading to contamination of water both local and distant. Contaminated fish and shell fish can reach humans through the food chain.

Atrazine

Atrazine is the most widely used corn and sorghum herbicide in the U.S., with domestic use estimated at about 70 million pounds per year. Atrazine=s half life in soil is about 60 days, and is removed from soil by a variety of mechanisms including hydrolysis, biodegradation, and volatilization. Atrazine persists in water sources considerably longer, and is found in many surface waters and ground water sources in corn growing areas. Although annual MCL (maximum contaminant level set by U.S. EPA as a drinking water standard) values are rarely exceeded, localized peak values above the MCL following rainfall events after application of atrazine do occur.

To reduce water contamination, application rates have been reduced and buffer zones from surface water have been established. Atrazine is presently registered for use as a restricted use pesticide, which requires its use only by trained and certified applicators. Atrazine is under special review by U.S. EPA along with the other triazine herbicides, which may result in further restrictions of use.

Potential Harmful effects:

- **$** possible human carcinogen (Group C) based upon an increase in mammary gland tumors in female laboratory animals

Sources:ATSDR Toxicological Profiles, U.S. EPA Office of Pesticide Programs and www.nwf.org/nwf/greatlakes/gli/bccs.html

Report Overview

The grant and contract summary information in this report was gathered from several sources. The AGreat Lakes Program Project Summaries@ were helpful for an initial collection of all Lake Michigan Mass Balance Grants, 1993 to 1997. Detailed information was found in the corresponding grant and contract files and Quality Assurance Plans in GLNPO=s Region 5 office. The proposals were often used for the narratives in the individual summaries. Because much of the information was outdated and hard to track, the project officers (PO) and principal investigators (PI) supplied helpful insights. Both parties, PIs and POs, were given the opportunity to review the individual summaries for accuracy; appropriate changes were made. Information is current as of September, 1998.

The following information is provided, where applicable and available, for each grant and contract:

- **Heading**: Project title, the year the project began, the grant/contract tracking number, and the grantee/contractor=s affiliation

- **Contact**: In most cases this is the name of the Principal Investigator, the lead individual who preformed the tasks set in the proposal or contract, for the grantee or contractor

- **Award Amount:** The cumulative amount awarded by GLNPO to the grantee/contractor

- **Dollars Leveraged:** The approximate amount contributed by the grantee; a minimum 5 percent match by the recipient is required by GLNPO

- **Project Timetable:** The start-date and prospected end-date

- **GLNPO Project Officer:** A contact in GLNPO who supervised the grant/contract or someone who has taken these responsibilities from the previous officer

- **Narrative:** A short summary of the project proceedings

- **Objectives:** The goals of the project

- **Status:** This indicates whether the project is complete or continuing

- **Data Results**: An indication as to what was collected, ie. information or samples

- **Environmental Results/Products**: Some benefits ensuing from the grant/contract, in relation to the original aims

- **Additional Sources**: Publications and other relevant, documented information which are a product of the project

Grants and Contracts - 1993

Management of Michigan Great Lakes Atmospheric Deposition (GLAD) Sites (FY 1993-GL995334)
University of Illinois

Contact: Scott R. Dossett
Illinois State Water Survey
2204 Griffith Dr.
Champaign, IL 61820
(217)244-0372
(217)332-0249 FAX
sdossett@uiuc.edu

Award Amount: $34,958

Dollars Leveraged: $8,686

Project Timetable: June 1,1993-May 31,1994

GLNPO Project Officer: Angela Bandemehr (312)886-6858

Narrative: Funds for this grant support the operation and management of the Lake Michigan Mass Balance (LMMB) for nutrient precipitation. Funds are also provided for the shutdown of other GLAD sites in Lakes Michigan and one in Superior and Huron.

Project **objectives** include:

- **$** Continuing the management duties for six Michigan GLAD sites
- **$** Ensuring the routine and proper collection of precipitation samples and their timely delivery for chemical analysis
- **$** Serving as the go-between for the Great Lakes National Program Office (GLNPO) and site operators
- **$** Providing for site operation reimbursement

Status: closed

Data Results: GLAD sites were successfully shutdown and all the samples were analyzed.

Environmental Results/Products: An important strategy of GLNPO is to reinforce the significance of the GLAD network as Aan important source of (deposition) information@. This information is to be made available to others for research, providing the potential for further environmental benefits.

Lake Superior/Michigan Atmospheric Loading Network (FY 1993-GL995022)
Wisconsin Department of Natural Resources

Contact: Thomas Sheffy
101 S. Webster St.
P.O. Box 7921
Madison, WI 53707
(608)267-7648
(608)267-0560 FAX
shefft@dnr.state.wi.us

Award Amount: $98,975

Dollars Leveraged: $5,215

Project Timetable: October 1, 1993-September 30, 1995

GLNPO Project Officer: Angela Bandemehr (312)886-6858

Narrative: This funding is provided to the WDNR for the maintenance and operation of Wisconsin atmospheric monitoring sites included in the Lake Michigan Mass Balance and Lake Superior Loading Study. Samples (air and precipitation) are collected by WDNR and sent to the Illinois State Water Survey for analysis for PCBs, PAHs, organochlorine compounds and trace metals.

Project **objectives** include:

- **$** Measuring pollutant loads to the Lakes so that the relative contribution of atmospheric sources to total lake loading can be determined
- **$** Tracking toxic loading
- **$** Identifying major source categories
- **$** Assisting in pollution prevention and source control strategy development
- **$** Assisting in the eventual development of mass balance models

Status: closed

Toxic Atmospheric Deposition to Lakes Michigan and Superior(FY 1993-GL995483)
The University of Illinois(Illinois State Water Survey)

Contact: Clyde Sweet
2204 Griffith Dr.
Champaign, IL 61820
(217)333-7191
(217)333-6540 FAX
csweet@sws.uiuc.edu

Award Amount: $1,588,736

Dollars Leveraged: $80,000

Project Timetable: October 1, 1993-September 30, 1997

GLNPO Project Officer: Angela Bandemehr (312)886-6858

Narrative: Regional deposition of nutrients, trace metals and organic contaminants is now being monitored in the Great Lakes. Intense urban and industrial activity in areas of the Great Waters such as Chicago and Baltimore, overlooked until now, result in elevated concentrations of particles and chemicals which are easily transported over the water and removed by dry and wet deposition. This project will quantify the enhanced wet and dry atmospheric fluxes which result from emissions in these urban areas. This funding supports the analysis of atmospheric samples(air and precipitation) from the nine land-based, and one shipboard, air sampling sites of the Lake Michigan Mass Balance(LMMB) and Lake Superior Loading Study. Samples are analyzed for PCBs, organochlorine compounds, PAHs, and trace metals. Results are used to estimate atmospheric loadings to the lakes for use in mass balance models.

Project **objectives** include:

- **$** Determining the wet and dry depositional fluxes of critical urban contaminants to northern Chesapeake Bay and southern Lake Michigan
- **$** Determining contributions of urban source categories to measured atmospheric concentrations and deposition
- **$** Determining the air-water exchange of contaminants and their partitioning into aquatic phases

Status: The project was extended form Sept. 13, 1996 to Sept. 30, 1997. It is in the process of being closed out.

Data Results: Data from nine land-based sites and ship board air sampling sites were received and verified by EPA. Data show that the Chicago urban area generally has the highest concentrations of most organic contaminants and metals (i.e. PCBs, DDT, PAHs, ZN, PB). Also, a north-south gradient of contaminants was seen, the north having lower concentrations.

Environmental Results/Products: This data will be used in the LMMB modeling effort to model PCBs, Hg, trans-nonachlor, and atrazine in Lake Michigan. The model will be a tool for environmental mangers to help predict the efficiency of particular toxic reduction strategies.

Additional Sources:

Cortes, D.R., I. Basu, C.W. Sweet, K.A. Brice, R.M. Hoff, and R.A. Hites, 1998. Temporal Trends in Gas-Phase Concentrations of Clorinated Pesticides Measured at the Shores of the Great Lakes. *Environ. Sci. Technol.* 32: 1920-1927.

Sweet, C.W., S.J. Vermette and A. Weiss, 1998. Atmospheric Deposition of Trace Metals at Three Sites near the Great Lakes. *Water Air & Pollut*. 103:423-439.

Hillery, B.R., I. Basu, C.W. Sweet, and R.A. Hites, 1997. Temporal and Spatial Trends in a Long Term Study of Gas-Phase PCB Concentrations near the Great Lakes. *Environ. Sci. Technol*. 31:1811-1816.

Sweet, C.W. and K.S. Harlin, 1997. Toxic Organics and Trace Metals in Air and Precipitation near Lake Michigan. Paper 97-TA121.04, Proceedings of the 90th Annual Meeting of the Air and Waste Management Association, Toronto, Ontario, June 8-13, Air and Waste Management Association, Pittsburgh, PA 15222.

Grants and Contracts - 1994

Preparation of XAD-2 Sampling Columns and Analysis of Open-lake Water Column Samples in Support of LMMB Project (FY 1994-DW89947684)
U.S. Department of Energy

Contact: Eric A. Crecelius
Battelle Marine Science Laboratory
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Sequim, WA 98382
(360)681-3604
(360)681-3699 FAX
eric.crecelius@pnl.gov

Award Amount:$1,401,013

Dollars Leveraged: $70,050

Project Timetable: February 1,1994-September 30,1997

GLNPO Project Officer: Glenn Warren (312)886-2405

Narrative: This award will provide the necessary laboratory support for the open-lake monitoring portion of the Lake Michigan Mass Balance (LMMB). It covers the preparation of sampling equipment and the analytical chemistry for two of the LMMB target parameters, polychlorinated biphenyls (PCBs) and Trans-nonachlor.

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Project **objectives** include:

- **$** Conducting open lake water column sampling to collect the dissolved and the suspended particulate phase of PCBs and trans-nonachlor
- **$** Performing laboratory analysis of the filtered particulates and the XAD-2 Resin samples generated during the sampling cruises for PCBs and trans-nonachlor
- **$** Providing the EPA with data of known quality in a useable format

Status: closed

Data Results: The concentrations of PCBs at the congener level have been analyzed for samples from seven surveys of Lake Michigan. The surveys began in April, 1994 and ended in October, 1995. During the surveys samples were taken from all parts of the lake, from one or more depths at each sampling station, depending on the season. All PCB concentration data from the surveys have been submitted to the Great Lakes National Program Office (GLNPO), and are being checked for data quality. Data will be made available to the group of mathematical modelers requiring it as soon as possible. General access to the PCB data depends on the final development of the GLNPO database.

Environmental Results/Products: This is the most comprehensive set of PCB data ever collected for a lake. The concentration data will be used in determining the total mass of PCBs in the lake, and also to determine the exposures, over their lifetimes, of the components of the food web. With this knowledge, we will help predict the levels of PCBs in top predator fish (lake trout

and coho salmon), and how our efforts to reduce contaminants in the lake will effect the concentrations of PCBs in the fish, and the risks associated with eating those fish.

Food Chain Studies and Contaminant Analysis in Support of LMMB (FY 1994-DW14947692)
U.S. Geological Survey, Great Lakes Science Center

Contact: John E. Gannon
1451 Green Road
Ann Arbor, MI 48105
(734) 994-3331
(734) 994-8780 FAX
john_e_gannon@usgs.gov

Award Amount: $1,825,382

Dollars Leveraged: $859,652

Project Timetable: April 1, 1994- September 30,1998

GLNPO Project Officer: Paul Bertram (312) 353-0153

Narrative: This multi-part Interagency Agreement (IAG) will provide biological information required for the successful completion of the Lake Michigan Mass Balance (LMMB). The data obtained through this effort will subsequently be used to develop or calibrate components of the food web model for the transport of contaminants from water to the top predator fish in Lake Michigan. It will also provide information on relative contributions of these major prey species to the diet of lake trout with respect to growth, energy density, condition, and fecundity of the trout.

Project **objectives** include:

- **$** Collecting lake trout and forage fish for contaminant analysis
- **$** Chemically analyzing the contaminants in the lake trout, coho salmon, forage fish, and macro invertebrates
- **$** Assessing lake trout and forage fish diets
- **$** Determining the coho salmon growth rates

Status: ongoing

Data Results: All biological and chemical analyses in accordance with the original agreement are completed. Included were 1875 sample analyses for lake trout diet, 1344 sample analyses for forage fish diet, and 829 analyses of contaminants in lake trout, coho salmon and forage fish. Interpretation of the data is still in progress.

Environmental Results/Products: Data are continuing to be reported the Great Lakes National Program Office and to the modelers at the EPA Large Lakes Research Station. These results will be critical to the structure and calibration of the food web submodel for the LMMB study. The data are being summarized and will be included in LMMB data reports and posted on the Internet. Manuscripts are being submitted to scientific journals.

Additional Sources:

Madenjian, C. P., T. J. DeSorcie and R. M. Stedman., 1998. Ontogenic and spatial patterns in diet and growth of lake trout in Lake Michigan. *Trans. Am. Fish. Soc.* 127:236-252.

Madenjian, C. P., T. J. DeSorcie and R. M. Stedman., 1998. Maturity schedules of lake trout in Lake Michigan. J. *Great Lakes Res*. 24:404-410.

Madenjian, C. P., R. J. Hesselberg, T. J. DeSorcie, L. J. Schmidt, R. M. Stedman, R. T. Quintal, L. J. Begnoche and D. R. Passino-Reader, 1998. Estimate of net trophic transfer efficiency of PCBs to Lake Michigan lake trout from their prey. *Environ. Sci. Technol*. 32:886-891.

Madenjian, C. P., R. F. Elliott, L. J. Schmidt, T. J. DeSorcie, R. J. Hesselberg, R. T. Quintal, L. J. Begnoche, P. M. Bouchard and M. E. Holey, 1998. Net trophic transfer efficiency of PCBs to Lake Michigan coho salmon from their prey. *Environ. Sci. Technol*. 32:in press.

Mercury Deposition and Cycling in the Lake Michigan and Lake Superior Basins (FY 1994-GL995569)
University of Michigan

Contact: Gerald Keeler
University of Michigan
Department of Environmental and Industrial Health
1530 SPH I
Ann Arbor, MI 48109-2029
(734)936-1836
(313)764-9424 FAX
jkeeler@sph.umich.edu

Award Amount: $333,629

Dollars Leveraged: $21,566

Project Timetable: March 15,1994-December 31,1996

GLNPO Project Officer: Angela Bandemehr (312)886-6858

Narrative: To investigate the levels and atmospheric transport of mercury in the Lake Michigan region and to investigate the emission and transformation of atmospheric mercury in urban/source regions, the University of Michigan Air Quality Laboratory (UMAQL) will initiate atmospheric mercury measurements. The University of Michigan will collect and analyze samples for vapor-phase, particle-phase and precipitation mercury in support of the Lake Michigan Mass Balance (LMMB). The grantee will provide an analysis of the data including estimates of the atmospheric loadings of total mercury to Lake Michigan and source receptor modeling.

Project **objectives** include:

- **$** Evaluating the atmospheric loading rate for comparison with other loads on the lakes to better target future load reductions and establishing a baseline loading estimate to gauge future progress
- **$** Providing atmospheric load information for development of a mass balance model for parameters not addressed by the LMMB.

Status: closed

Environmental Results/Products: The information gained will eventually be available for use in the LMMB Model. Obtaining an estimate of these loadings, as well as a predictive tool to estimate the effects of various emission reduction strategies, the Great Lakes National Program Office (GLNPO) will meet the objectives of the Great Lakes Water Quality Agreement (GLWQA) and 1992 Clean Air Act Amendment (CAAA) in a responsible and equitable manner with respect to ecological, economic, and recreational interests.

Direct Measurement of Dry Deposition (FY 1994-GL995572)
Illinois Institute of Technology

Contact: Dr. Thomas M. Holsen
Department of Civil and Environmental Engineering
R.J. Rowley Laboratory
Clarkson University
PO Box 5710
Potsdam, NY 13699
(315)268-3851
(315)268-7636 FAX
holsentm@draco.clarkson.edu

Award Amount: $195,231

Dollars Leveraged: $10,275

Project Timetable: March 1,1994-June 30,1997

GLNPO Project Officer: Angela Bandemehr (312)886-6858

Narrative: One of the central goals of the Lake Michigan Mass Budget/Mass Balance Study is to provide accurate estimates of the dry deposition inputs of critical contaminants to Lake Michigan. In this part of the Lake Michigan Mass Balance (LMMB), dry deposition samples are collected and analyzed for trace metals, trace organic compounds and mass. Data will be used to assess loadings to the lake. Intensive studies will include the direct measurement of dry deposition using the Eagle sampler on land and from the R/V Lake Guardian.

Project **objectives** include:

- **$** Directly measuring the dry deposition of metals and selected semi-volatile organic chemicals at five sites during the LMMB study
- **$** Comparing dry deposition measurements taken simultaneously over land and over water
- **$** Determining how sampling times and atmospheric conditions affect these measurements

Status: closed-was extended to June 30, 1997 and then closed out.

Data Results: Measurements of dry deposition were taken at four land-based sites and one ship-board site testing innovative sampling techniques.

Environmental Results/Products: The final product of the project is estimates of dry deposition inputs to Lake Michigan for the compounds studied. These estimates are available for comparison to estimates made with traditional techniques.

Additional Sources:

Franz, T.P., Eisenreich, S.J., and Holsen, T.M, July 1998. Dry Deposition of Particulate Polychlorinated Biphenyls and Polycyclic Aromatic Hydrocarbons to Lake Michigan, Accepted by *Environmental Science and Technology*.

Sivadechathep, J., 1997. Dry Deposition Velocities and Source Apportionment of Elements Using Data Collected Around Lake Michigan, PhD Thesis, Illinois Institute of Technology.

Lu C.S., 1996. Mass Balance of Lake Michigan: Dry Deposition PhD Thesis, Illinois Institute of Technology.

DynCorp Contract: 68-C3-0337(FY 1994-FY1998), 68-C-98-139 (FY 1998)

Contact: Lynn Riddick
DynCorp, I&ET, Inc.
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riddickl@dyncorp.com

Judy Schofield
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6101 Stevenson Ave
Alexandria, VA 22304
(703)461-2027
(703)461-8056 FAX
schofiej@dyncorp.com

Award Amount: $480,000

Project Timetable: 1994-1999

GLNPO Project Officer: William Telliard, Office of Water Engineering and Analysis Division (202)260-7134

Narrative: Support areas include assisting the Great Lakes National Program Office (GLNPO) with implementation of the Lake Michigan Mass Balance study (LMMB) component of the Enhanced Monitoring Program (EMP). Specifically, providing GLNPO with QA expertise and technical support for sampling and analysis of trace-level mercury and other metals. DynCorp also supports GLNPO towards the development of comprehensive data and QA reports for the LMMB study.

Project objectives include:

- **$** Developing techniques for evaluation of data supporting the Lake Michigan Mass Balance Project, with special emphasis on mercury and biological communities
- **$** Developing reports on statistical assessment of quality assurance (QA) data collected in LMMB program for each data focus and coordinate peer review of the reports and statistical approaches
- **$** Providing database/RDMQ support to LMMB, quality assurance staff, principal investigators, and project officers.
- **$** Assisting in the technical coordination of the LMMB, methods compendium and a quality assurance report.

Status: ongoing

Data Results: Several focuses of mercury data have been verified.

Environmental Results/Products: Data are documented as Aquality@ data.

Great Lakes Analytical Services (GLAS) Contract #68-R6-0001 at the Central Regional Laboratory in Chicago.
Grace Analytical Laboratory

Contact: Michael Flynn, Project Manager
536 South Clark Street 10th Floor
Chicago Illinois 60605
(312)886-7021
(312)886-2591 FAX

Award Amount used toward LMMB(1994 to Present): $2,920,167.08

Project Timetable: 1994-present. The present contract consists of a base year (June 1, 1996 to May 31, 1997) and four option years.

GLNPO Project Officer: Francis A. Awanya (312)886-3682

Narrative: A portion of the funds allocated under this contract support the Lake Michigan Mass Balance (LMMB) studies under the work assignments (WA) for Limnology and Inorganic Chemistry, Biological Monitoring, Enhanced Monitoring Quality Assurance (QA) Support, Trace Organic, and Project Management/Support. The role of the Project Management/Support WA was to manage resources allocated for the completion of the objectives of the rest of the above mentioned work assignments.

Project **objectives** include**:**

- **$** Providing chemical and biological data analyzed on the GLAS contract to support the LMMB study
- **$** Verifying data received by GLNPO from principal investigators
- **$** Providing a final LMMB QA report to GLNPO

Status: ongoing

Data Results: Verified environmental data provided to GLNPO for use.

1. <u>Enhanced Monitoring Program Quality Assurance (EMP-QA) Support:</u>

Contact: Debra Piper (Contractor) (312)886-7021
Grace Analytical Laboratory

Narrative: The EMP-QA Support provided technical assistance to GLNPO for on-site audit of participating laboratories. During those audits, assistance was provided to the Principal Investigators (PI)s to ensure full compliance with the necessary requirements for environmental data collection, and the development of QA Project Plans to facilitate those measurement objectives. A Performance Evaluation program was also implemented and the analyses results scored to evaluated participating laboratory performance.

Data received in electronic format from the Principal Investigators are verified for format, completeness, and accuracy using RDMQ. All verification flags are resolved with the appropriate Principal Investigator prior to final loading of results into GLENDA.

Project Objective: Provide verified data for GLNPO GLENDA data base.

Environmental Results: Provide Quality data for decision making.

2. Limnology and Inorganic Chemistry:

Contact: Mike Yussim (Contractor) (312)886-7021
Grace Analytical Laboratory

Narrative: Samples collected during the LMMB surveys for inorganic analyses were received and analyzed at the Central Regional Laboratory (CRL). Some analyses were performed on board the R/V Lake Guardian. Lake water samples collected were assayed for anions such as chloride, silica, nitrate/nitrite nitrogen, total Kjeldahl nitrogen (TKN), total phosphorus (TP), and total dissolved phosphorus (TDP) as requested for a given station.

Project Objective: Provide accurate concentration of a target inorganic analyte for GLNPO LMMB Program.

Environmental Results: Provide quality data for GLNPO LMMB Program.

3. Biological Monitoring:

Contact: Michael Flynn (Contractor) (312)886-7021
Grace Analytical Laboratory

Narrative: Samples collected for phytoplankton and zooplankton analysis were received for species identification at the Central Regional Laboratory (CRL). Other samples were collected and preserved for chlorophyll analyses at the CRL. Primary productivity incubations were performed on board the R/V Lake Guardian and follow up sample analysis were done at the CRL.

Project Objective: Provide accurate species identification, chlorophyll concentrations, and primary productivity data for the GLNPO LMMB program.

Environmental Results: Provide quality data for GLNPO LMMB Program.

4. Trace Organic:

Contact: Michael Flynn (Contractor) (312)886-7021
Grace Analytical Laboratory

Narrative: Samples collected during the LMMB surveys for Dissolved Organic Carbon(DOC), Particulate Organic (POC) and Total Suspended Solid (TSS) analyses were received and analyzed at the Central Regional Laboratory (CRL).

Project Objective: Provide accurate concentrations of analytes for GLNPO LMMB Program

Sediment Sampling and Analysis for LMMB (FY 1994-DW13947696)
National Oceanic and Atmospheric Administration(NOAA)

Contact: Dr. Brian Eadie
NOAA, Great Lakes Environmental Res Lab
2205 Commonwealth Blvd.
Ann Arbor, MI 48105
(734)741-2281
(734)741-2055 FAX
eadie@glerl.noaa.gov

Award Amount: $684,830

Dollars Leveraged: $250,000

Project Timetable: June 1, 1994-May 31,1997

GLNPO Project Officer: Glenn Warren (312)886-2405

Narrative: The main operations of this project are to measure the gross downward fluxes of particulate material and organic carbon; collect samples of the resuspendible pool of materials in regions of the lake where modern sediments do not accumulate; and provide samples of these materials for target compound analysis. The project coordinated sampling of sediment samples from a large number of sites in Lake Michigan to provide the subject information, collection of samples from sediment traps deployed in several locations in the lake, and analysis of the samples for contaminants and nutrients. An additional project item was the measurement of Aresuspendibility@ of the sediments in several areas of the lake.

Project **objectives** include:

- **$** Obtaining an accurate estimate of settling flux for particulates and contaminants associated with them
- **$** Providing a comprehensive sediment survey of Lake Michigan including surface sediment samples and cores at selected stations
- **$** Analyzing contaminants in the surface one centimeter of sediment, material collected in sediment traps and in selected sediment cores

Status: closed

Data Results: Data from sediment nutrient analyses and from contaminant analyses of surface sediment and sediment trap samples have been received. Availability is pending, dependent on an assessment of the quality of the data and its upload to our database.

Environmental Results/Products: The data are import in establishing the amount of contaminants trapped in the sediment of the lake and how this sediment moves through the water.

Additional Sources:

Eadie, B.J., 1997. Probing particle processes in Lake Michigan using sediment traps. *Water, Air, and Soil Pollution.* 99: 133-139.

Fate and Transport of Atrazine and Metabolites in the Great Lakes (FY 1994-GL995592)
University of Minnesota

Contact: Dr. Steven J. Eisenreich
Department of Environmental Science
Rutgers University
14 College Farm Rd.
New Brunswick, NJ 08901-8551
(732)932-9185
(732)932-8644 FAX
Eisenreich@envsci.rutgers.edu

Award Amount: $131,031

Dollars Leveraged: $6,965

Project Timetable: April 22,1994-December 31,1996

GLNPO Project Officer: Glenn Warren (312)886-2405

Narrative: This project supports the Lake Michigan Mass Balance Study. Samples from the open waters of Lake Michigan as well as eleven major tributaries to the lake, will be analyzed for Atrazine and its breakdown products, deethyl atrazine and deisopropyl atrazine. Alachlor and Metolachlor will also be quantified. The data will contribute to a mass balance model. The persistence of the herbicides in the Great Lakes will be determined.

Project **objectives** include:

- **$** Providing data on the concentration of atrazine and metabolites in Lake Michigan and its distribution in the water.
- **$** Providing data on the concentration of atrazine in the major tributaries that flow into Lake Michigan

Status: closed

Data Results: All samples have been analyzed, results submitted, and have passed quality assurance review. They will be available upon upload to our database.

Environmental Results/Products: These data provide information on the concentration of the most heavily used herbicide in the Great Lakes basin. Concentration information on tributaries will identify which are contributing significant amounts of the herbicide to Lake Michigan. The U.S. EPA is currently re-evaluating atrazine for registration purposes, and will use the data in their work.

Collection of Coho Salmon for Contaminant Analysis and Determination of Diet for the Lake Michigan Balance Study (FY 1994-DW14947693)
U.S. Fish and Wildlife Service

Contact: Mark E. Holey
USFWS/Green Bay Fishery Resources Office
1015 Challenger Court
Green Bay, WI 54311
(920) 465-7440
(920) 465-7410 FAX
mark_holey@mail.fws.gov

Award Amount: $218,235

Dollars Leveraged: $10,912

Project Timetable: April 1, 1994-September 30, 1996

GLNPO Project Officer: Paul Bertram (312)353-0153

Narrative: The aim of this project is to collect coho salmon for contaminant analysis and to determine coho food habits during 1994 and 1995 as part of the Lake Michigan Mass Balance (LMMB). This effort will provide important information about one of the three target fish species identified in the LMMB Work Plan. The contaminant burden and diet information will subsequently be used to develop a model to describe contaminant flow through the Lake Michigan food web to coho salmon.

Project **objectives** include:

- **$** Collecting 225 coho salmon for analysis of contaminant burden
- **$** Determining the coho salmon diet based on stomach contents
- **$** Reviewing available literature to assess if 1994 was a typical year for coho salmon diet

Status: closed

Data Results: Coho salmon were sampled from April through November of 1994-95 throughout Lake Michigan to describe their diet and provide samples for contaminant analysis as part of the food web modeling for the Lake Michigan Mass Balance Project. Of the 1892 coho salmon collected, 301 were packaged into 67 composites for contaminant analysis, and 1383 stomachs were analyzed for diet.

Percent diet composition (wet weight), prey weight, and prey length frequency were the primary statistics used to analyze the data. Summarized data was reported by region, month, and predator age. Large alewife (130-225 mm) dominated the diet of adult coho, accounting for 31-88% of their April-May diet and 75-98% of their June-September diet by weight. The 1994 year class of alewife also contributed as YOYs (<60 mm) in 1994 and yearlings (<120 mm) in 1995. While they were the dominant prey fish of juvenile coho, they contributed 30% or less to adult coho diet. Insects contributed up to 40% of the adult coho salmon diet in the spring, and *Bythotrephes*

contributed up to 78% of the juvenile coho diet in summer and fall. Rainbow smelt, *Diporeia* and threespine sticklebacks occurred seasonally in some regions but were of minor contribution overall.

These results differ substantially from 1985-86 diet data, and reflect changes in prey availability. The 1985-86 coho diet was dominated by smaller alewife, juvenile bloater, yellow perch and rainbow smelt, with relatively few adult alewives found compared to 1994-1995. Coho size and total stomach contents in 1985-86 were less than was observed in 1994-95. These findings have implications for the potential dynamics of contaminant accumulation by salmonines in Lake Michigan.

Environmental Results/Products: The Products of this work included: 1) grouping into composites and the delivery of the number of coho necessary for the contaminant analysis, and 2) delivery of a report describing the diet of coho sampled for diet in 1994 and 1995, and the diet of coho as determined from recent historical data.

Additional Sources:

Elliott, R. F.; and eight other co-authors, 1996. Conducting Diet Studies of Lake Michigan Piscivores, A Protocol. Report No. 96-2; U. S. Fish and Wildlife Service: Green Bay, WI..

Madenjian C. P.; Elliott, R. F.; and 7 other co-authors, 1998, in press. Net Trophic Transfer Efficiency of PCBs to Lake Michigan Coho Salmon from Their Prey. *Environmental Science and Technology.*

Customization and Implementation of the Research Data Management and Quality Control System (FY 1994-GL995563)
Environment Canada

Contact: Bill Sukloff
Air Quality Research Branch
Atmospheric Environment Service
Environment Canada
4905 Dufferin Street
Toronto, Ontario M3H 5T4 Canada
(416)739-5722
bill.sukloff@ec.gc.ca

Award Amount: $83,790

Dollars Leveraged: $4,189

Project Timetable: March 21, 1994-April 1, 1996

GLNPO Project Officer: Louis Blume (312)353-2317/Angela Bandemehr (312)886-6858

Narrative: Research Data Management and Quality Control(RDMQ) system is being developed for use by various air quality measurement networks and all of Lake Michigan Mass Balance (LMMB) chemistry data.. The use of RDMQ by the US-GLNPO would foster easy exchange of quality-assured data collected for the Great Lakes Basin. Funding provides for the development of a Research Data Management and Quality Control software package for use in GLNPO. Environment Canada will be modifying RDMQ for GLNPO applications such as the LMMB Study. The software will facilitate data verification and flagging for the Lake Michigan Mass Balance study.

Project **objectives** include:

- **$** Achieving the goal of an integrated US-Canada Integrated Atmospheric Deposition Network (IADN) data base
- **$** Reducing the time required to produce quality controlled data bases form both backlogged data sets and data to be collected in the future
- **$** Serving as the primary data verification tool for Lake Michigan Mass Balance Data

Status: closed

Data Results: Currently RDMQ has successfully been developed and utilized for verification of 40% of LMMB chemistry data.

Environmental Results/Products: A Data verification software system for use in our base monitoring program was produced.

Additional Sources:

Bill Sukloff, Syd Allen, 1995. The Research Data Management and Quality Control System(RDMQ) User Manual, 1-83.

http://airquality.tor.ec.gc.ca/rdmq

Collection and Analysis of Total Mercury in the Lake Michigan Water Column (FY 1994 - GL995593)
Chesapeake Biological Laboratory, University of Maryland

Contact: Robert P. Mason
P.O. Box 38
Solomons, MD 20688
(410)326-7387
(410)326-7341 FAX
mason@cbl.umces.edu

Award Amount: $70,925

Dollars Leveraged: $3,546

Project Timetable: May 1, 1994-April 30,1995

GLNPO Project Officer: Glenn Warren (312)886-2405

Narrative: This grant addressed the measurement of total mercury in the waters of Lake Michigan during the study period of the Lake Michigan Mass Balance Study. In addition to samples taken for total mercury analysis, others were taken specifically to look at the bioaccumulative form of mercury in the environment, monomethylmercury. The study examined the processes involved in aquatic systems in the production and cycling of monomethylmercury(CH3Hg), the Hg compound that prevails in fish. Success in the Lake Michigan study depended on two factors: reliable, ultra trace analytical methods and non-contaminating sample collection procedures.

Project **objectives** include:

- **$** Measuring total mercury in samples taken throughout Lake Michigan using clean techniques
- **$** Measuring levels of monomethyl mercury in selected samples

Status: closed

Data Results: All samples have been analyzed, results submitted, and passed quality assurance review. Data will be available pending upload to our database. Results have been published in the peer reviewed literature.

Environmental Results/Products: The results will be incorporated into the Lake Michigan Mass Balance Model. This model and the study are designed to provide good scientific information to environmental managers whose concern is toxic contaminants in the environment.

Additional Sources:

Mason, R.P. and Sullivan, K.A.,1997. Mercury in Lake Michigan, *Environmental Science and Technology*. 31: 842-947.

Mason, R.P. and Sullivan, K.A., 1998. The concentration and distribution of mercury in Lake Michigan, *Science of the Total Environment*. 213: 213-228.

Grants and Contracts - 1995

Lake Michigan Mass Balance Public Awareness Campaign(FY 1995-GL985106)
Lake Michigan Federation

Contact: Tanya Cabala and Liz England
161 Muskegon Mall
Suite 502
Muskegon, MI 49440
(616)722-5116
(616)722-4918 FAX
lkmf@novagate.com

Award Amount: $85,650

Dollars Leveraged: $4,412

Project Timetable: September 15, 1995-March 1999

GLNPO Project Officer: Angela Bandemehr (312)886-6858

Narrative: It is vitally important to provide decision-makers and the public with a greater understanding of the problems facing Lake Michigan and the results to be expected from implementing proposed actions. Materials will be developed for a program that will increase public awareness and understanding of past and present problems facing the Lake Michigan ecosystem and the initiatives, with an emphasis on the Lake Michigan Mass Balance Project, underway to improve the health of the Lake.

Project **objectives** include:

- **$** Increasing public awareness/understanding of past and present problems facing the Lake Michigan ecosystem and the initiatives, with an emphasis on the Lake Michigan Mass Balance Project, underway to improve the health of the Lake
- **$** Publicizing and updating activities, progress, and results of the Lake Michigan Mass Balance Study

Status: ongoing

Environmental Results/Products: A database for interested parties is maintained. Articles on the study appear in the *Lake Michigan Monitor*, Lake Michigan Federation's quarterly newsletter, which has a broad 4-state mailing list. An informative power point presentation is available, as well as fact sheets and full color posters. Presentations on the study will be made in Lake Michigan Basin communities and articles written for journals and magazines.

Additional Sources:

Additional information can be viewed at Lake Michigan Federation's web site at www.lakemichigan.org/balance.html

ORACLE Contract:68-W2-0033, American Management Systems, Inc. (AMS)
Subcontract: 12794(FY 1995)

Contact: Jeffrey R. Sabol
American Management Systems, Inc.
120601 Fairlakes Circle, 10th floor
Fairfax, VA 22033
(703)227-6841
(703)227-6704 FAX
jeffrey_sabol@mail.amsinc.com

Award Amount: $1,810,351

Project Timetable: May 5, 1995-1998

GLNPO Project Officer: Louis Blume (312)353-2317

Narrative: The Great Lakes national Program Office (GLNPO) has constructed an Oracle data base to store data generated by water quality, sediment, air, and biological monitoring conducted in the Great Lakes watershed. The short-term focus of the project is to accommodate data from the Lake Michigan Mass Balance Study (LMMB)..

Project **objectives** include:

- **$** Developing a long term relational data base for STORET compatible GLNPO
- **$** Developing data reporting formats for GLNPO cooperators
- **$** Developing standard reference and static data tables, codes, and definitions
- **$** Utilizing the Enhanced Monitoring Program as the pilot for implementation of the project

Status: ongoing

Environmental Results/Products: The Development of a relational data base to house LMMB data and GLNPO base program data.

Contaminant Transfer in Lake Michigan Lower Pelagic Foodweb (FY 1995-GL995616)
University of Minnesota

Contact: Deborah L. Swackhamer
Box 807 Mayo Building
University of Minnesota
Minneapolis, MN 55455
(612)626-0435
(612)626-0650 FAX
dswack@mail.eoh.umn.edu

Award Amount: $495,344

Dollars Leveraged: $28,745

Project Timetable: June 14, 1995-September 15,1998

GLNPO Project Officer: Glenn Warren (312)886-2405

Narrative: As part of the Lake Michigan Mass Balance Study, this project was a key part of the foodweb bioaccumulation modeling effort. Samples of phytoplankton and zooplankton, Diporiea and Mysis were taken throughout the course of the study and analyzed for PCBs, trans-nonachlor and mercury.

Project **objectives** include:

- **$** Developing and implementing the methods used to collect phytoplankton and zooplankton samples from open lake stations in Lake Michigan by the R/V Lake Guardian
- **$** Determining the concentrations of target analytes in phytoplankton and zooplankton samples collected during open water surveys
- **$** Developing and calibrating a dynamic, predictive model for estimating contaminant concentration in phytoplankton and zooplankton from known water concentrations

Status: closed

Data Results: All data on PCB and trans-nonachlor concentrations in plankton have been submitted, and are undergoing quality assurance review. They will be available sometime in 1999.

Environmental Results/Products: These data will give us a better understanding of the bioaccumulation of contaminants in the lower food web of Lake Michigan. The development of this information will be transferrable to other bodies of water.

Building State Capacity Great Lakes Multi-Media/*Air Toxics Conference(LMMB)* (FY 1995-GL995381)
Michigan Department of Environmental Quality

Contact: Michigan Department of Environmental Quality
Office of the Great Lakes
(517)335-4056

Award Amount: $212,675/$4,600(money specifically used on the LMMB Conference)

Dollars Leveraged: $12,915/$230(specifically from LMMB Conference)

Project Timetable: June 14 and 15, 1995

GLNPO Project Officer: Mark Elster (312)886-3857
Technical: Glenn Warren (312)886-2405

Narrative: A portion of the money funded by the MDNR=s large grant, ABuilding State Capacity Great Lakes Multi-Media,@ was used to fund the Lake Michigan Mass Balance (LMMB) Air Toxics Conference on June 14 and 15, 1995. This workshop facilitated exchange of information and ideas between various areas of expertise and will result in a document directing the air-water model linkages to be used in the Lake Michigan Mass Balance Model.

Project **objectives** include:

- **$** Holding a workshop to bring together key process researchers and air and water modeling experts form the US and Canada.

Status: closed

Environmental Results/Products: The MDNR hosted a workshop for air-water contaminant exchange modeling efforts associated with the Lake Michigan Mass Balance project, supporting the Lakewide Management Plan. The workshop supported the development of atmospheric loads, boundary/initial conditions, and process parameters for running the MICHTOX model that summer. The long term goal was to reduce uncertainty in loading calculations from regional atmospheric models.

Great Lakes Mass Balance Database Evaluation and Management Program(FY 1995-DW89947742)
U.S. Department of Energy, Argonne National Laboratory

Contact: Eric Zimmerman
Argonne National Laboratory
9700 S. Cass Ave 362/ES
Argonne, IL 60439-4815
(630)252-6816
(630)252-6407 FAX
eric_zimmerman@qmgate.anl.gov

Award Amount: $100,000

Dollars Leveraged: $5,000

Project Timetable: September 1, 1995-December 31, 1996

GLNPO Project Officer: George Mbogo (312)353-7463

Narrative: The purpose of the Great Lakes Mass Balance Database (GLMBD) is to provide a sound qualitative and quantitative analytical platform of source, constituent, and concentration data for contaminants. This information will enable the EPA to develop an accounting of various sources and sinks of pollutants in the Lake Michigan system. The mass balance database for the waterway system must be consistent, sound, and easily accessible to EPA managers.

In order to expedite access to the voluminous Lake Michigan Mass Balance datasets, the Department of Energy is providing its expertise in developing and managing complex computer database applications. The applications developed under this Interagency Agreement (IAG) will include data entry and data access. These applications will be applicable to all additional project datasets in the Great Lakes Monitoring Database.

Project **objectives** include:

- **$** Reviewing and evaluating the existing data
- **$** Developing methodologies for evaluation/determination of a data source/location associated to the industrial process
- **$** Developing a revised system that will enhance the existing database management system to allow the Great Lakes National Program Office (GLNPO) to achieve its legislatively mandated reporting and data-dissemination obligations

Status: ongoing: completed work transferred to an outside contractor

Data Results: none(prototype was not implemented)

Environmental Results/Products: This was the beginning of an ongoing development for LMMB projects. A more flexible desktop access to the dynamic data tables for defined (account-based) users will eventually be produced. The emphasis of this phase one user access interface

will be placed on generating datasets to be shared with secondary users and on elementary ability to edit/update dynamic data in an interactive fashion.

Grants and Contracts - 1996

Atmospheric Loading of Toxic Contaminants to Lake Michigan (FY 1996-GL985430)
The University of Michigan, the School of Public Health

Contact: Gerald Keeler
University of Michigan
Department of Environmental and Industrial Health
1530 SPH I
Ann Arbor, MI 48109-2029
(734)936-1836
(313)764-9424 FAX
jkeeler@sph.umich.edu

Award Amount: $97,637

Dollars Leveraged: $15,703

Project Timetable: October 1,1996-September 30, 1999

GLNPO Project Officer: Angela Bandemehr (312)886-6858

Narrative: Atmospheric deposition has been identified as a significant source of hazardous air pollutants(HAPs) to the Great Lakes. This project leads to estimates of the atmospheric loading of the toxic pollutants which are studied in Lake Michigan Mass Balance (LMMB). These estimates will be based on data collected as part of the Enhanced Monitoring Program, including simultaneous measurements of contaminants in air and water during lakewide mass balance surveys, and during intensive work sponsored by the U.S. EPA.

Project **objectives** include:

- Determining the portion of the atmospheric deposition loading of total mercury to Lake Michigan due to Awet deposition@. Estimates of the uncertainties associated with this calculation will also be addressed.
- Determining the portion of the atmospheric deposition loading of total mercury to Lake Michigan due to Adry deposition@. To achieve this latter objective, two sub-objectives will also need to be addressed: 1) the determination of dry deposition velocities and volatilization rates of the individual species, 2) the determination of vapor-phase concentrations for the individual species in the air-water interphase

Status: ongoing

Data Results: Using data from four land-based sites around Lake Michigan, loadings of total mercury to Lake Michigan are being calculated.

Environmental Results/Products: The information gained will eventually be available for use in the LMMB Model. Obtaining an estimate of these loadings, as well as a predictive tool to estimate the effects of various emission reduction strategies, the Great Lakes National Program Office (GLNPO) will meet the objectives of the Great Lakes Water Quality Agreement

(GLWQA) and 1992 Clean Air Act Amendment (CAAA) in a responsible and equitable manner with respect to ecological, economic, and recreational interests.

Estimation of Contaminant Emissions and Relevant Meteorological Conditions for the Lake Michigan Mass Balance Study Modeling Effort (FY 1996-DW13947769)
National Oceanic and Atmospheric Administration (NOAA)

Contact: Ellen Cooter
NOAA, Air Res. Lab, Atmospheric Sciences and Modeling Division
MD-80 Research Triangle Park, NC 27711
(919)541-1334
(919)541-1379 FAX
cooterej@hpcc.epa.gov

Award Amount: $280,000

Dollars Leveraged:$14,000

Project Timetable: October 1,1996-September 30,1999

GLNPO Project Officer: Angela Bandemehr (312)886-6858

Narrative: The purpose of this action is to authorize funding for an Interagency Agreement with the NOAA for the estimation of contaminant emissions and relevant meteorological conditions for the Lake Michigan Mass Balance Study modeling effort. These funds will enable the Atmospheric Sciences and Modeling Division of NOAA to acquire emissions model output and data products and to develop a meteorological data base which will subsequently be used in water quality models contributing to the Lake Michigan Mass Balance Study.

Project **objectives** include:

- **$** Estimating the contaminant emissions and meteorological conditions surrounding Lake Michigan
- **$** Developing a data base with the information

Status: ongoing-extended one year to Sept. 30, 1999.

Data Results: A soil emission model has been developed to estimate emissions of atrazine based on application rates. Some of the highest use of atrazine is in the Great Lakes Basin.

Environmental Results/Products: A sample access computer code and documentation adequate for appropriate application of a data base of meteorological conditions, Midwestern United States Atrazine emissions, and possibly Canadian Atrazine emissions will be produced. Also an hourly, wet, dry and gas phase deposition estimate of Atrazine and mercury will be made available.

Additional Sources:

Presentations:

Cooter, E.J., June 4, 1997. Fate and transport modeling of agricultural atrazine emissions to the Great lakes Basin: Step 1 - Linkage of terrestrial emissions and the atmospheric system components. Presented at the 40th Conference of the International Association for Great Lakes Research (IAGLR), Buffalo State College and University of Buffalo, Buffalo, NY.

Scholtz, M.T., E.J. Cooter and A.C. McMillan, June 4, 1997. Preparation of gridded hourly atrazine emissions from agricultural lands in the Great Lakes air shed. Presented at the 40th Conference of the International Association for Great Lakes Research (IAGLR), Buffalo State College and University of Buffalo, Buffalo, NY.

Cooter, E.J., J.R. Rhome, and J.B. Hill, October 20-23, 1997. Spring and summer 1995 regional climate conditions and the assessment of atrazine exposure in and around Lake Michigan. 10th Conference on Applied Climatology, Reno, Nevada.

Publications:

Cooter, E.J., J.R. Rhome and J.B. Hill, 1997. A Spring and summer 1995 regional climate conditions and the assessment of atrazine exposure in and around Lake Michigan.@ In Pre-prints of the 10th Conference on Applied Climatology, October 20-23, 1997, Reno, Nevada. American Meteorological Society: Boston, pp2-6.

In Preparation:

Cooter, E.J., J.R. Rhome, J.B. Hill and M.D. Schwartz. Application of an integrated air mass classification scheme to regional volatilization, transport and deposition of toxic chemicals.@ For submission to Journal of Applied Meteorology.

Atmospheric Deposition of PCBs, Trans-nonachlor, Atrazine, Nitrogen and Phosphorus to Lake Michigan (FY 1996-GL985427)
Research Foundation of State University of New York (SUNY)

Contact: Keri Hornbuckle
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kchorn@engineering.uiowa.edu

207 Jarvis Hall
Department of Engineering
State University of New York at Buffalo
(716)645-2114 ext2326
(716)645-3667 FAX
ciejfa@acsu.buffalo.edu

Award Amount: $209,671

Dollars Leveraged: $11,866

Project Timetable: October 1,1996-September 30,1999

GLNPO Project Officer: Angela Bandemehr (312)886-6858

Narrative: The relative importance of chemical inputs to the lake, especially atmospheric inputs, is poorly understood for nearly all chemicals. This poses a critical problem because atmospheric inputs exert a very strong influence in our ability to predict chemical behavior. This agreement will allow SUNY Buffalo to estimate atmospheric loadings of PCBs, Atrazine and trans-Nonachlor in support of the Lake Michigan Loading Study/Mass Balance (LMMB). This project runs parallel with the project entitled AAtmospheric Loadings of PCBs, t-Nonachlor and Atrazine, Nitrogen and Phosphorous to Lake Michigan Waters@.

Project **objectives** include:

- **$** Summarizing the current knowledge of atmospheric depositional processes
- **$** Reviewing and evaluating the data available from the LMMB
- **$** Estimating the atmospheric deposition and loadings to Lake Michigan of target compounds with respect to spatial and temporal variability
- **$** Calculating the uncertainty associated with atmospheric deposition of target compounds
- **$** Providing loading estimates in a format useful to the LMMB modeling effort

Status: ongoing-this project has been extended a year to Sept. 30,1999

Data Results: Initial estimates of loadings of PCBs, trans nonachlor, atrazine, nitrogen, and Phosphorus have been made. The loadings estimates are being refined based on improved

algorithms and discussion with EPA modelers. Results have been presented at a variety of conferences including the International Association of Great Lakes Research Conference (1997&1998). Loadings vary extensively both spatially and temporally depending on wind speed with direction and air temperature and proximity of sources.

Environmental Results/Products: The final results of this project will be delivered to the EPA LMMB modelers and will be wet deposition, dry deposition, and vapor phase concentrations of target contaminants at the air-water interface.

Additional Sources:

Miller, S.M.; Green, M.L.; DePinto, J.V. and Hornbuckle, K.C., October, 1997. The Influence of Sampling Site Location on Air-Water Exchange of Semivolatile Organic Compounds. Midwest Environmental Chemistry Workshop. Bloomington, IN.

Green, M.L.; DePinto, J.V. Green, M.L. and Hornbuckle, K.C., October, 1997. Large Scale Atmospheric Effects on Great Lakes Basin Contaminants. Midwest Environmental Chemistry Workshop. Bloomington, IN.

Miller, S.M. and Hornbuckle, K.C., May, 1997. Atmospheric Deposition of Semivolatile Organic Compounds to Lake Michigan: Statistical and Meteorological Integration of Shoreline and Over-Water Atmospheric Data. Annual Meeting of the International Association for Great Lakes Research (IAGLR). Buffalo, NY.

Green, M.L.; DePinto, J.V. Hornbuckle, K.C. and Miller, S.M. May, 1998. Temporal and Spatial Interpolation of Atmospheric Gas Phase PCB Measurements during the Lake Michigan Mass Balance Study. Annual Meeting of the International Association for Great Lakes Research (IAGLR). Hamilton, Ontario.

Miller, S.M.; Green, M.L.; DePinto, J.V. and Hornbuckle, K.C., May, 1998. An Investigation of Over-Water Sampling: a Case Study. Annual Meeting of the International Association for Great Lakes Research (IAGLR). Hamilton, Ontario.

Grants and Contracts - 1997

Verification of LMMB Coho and Lake Trout Diet Data (FY 1997-DW14947825)
U.S. Fish and Wildlife Service

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Award Amount: $11,305

Dollars Leveraged: $7,500

Project Timetable: August 1,1997-December 31,1998

GLNPO Project Officer: Paul Bertram (312)353-0153

Narrative: The lake trout and diet studies conducted for the LMMB Study during 1994-95 may not adequately represent long term predator/prey dynamics because of spacial and temporal limitations of the collections. Supplemental information on the diets of the lake trout and coho salmon collected during studies other than the LMMB study can be used effectively to verify or validate the representativeness of the LMMB diet data. The U.S. FWS will compile a report of the coho and lake trout diet information available for Lake Michigan from the 1980's through 1995.

Project **objectives** include:

- **$** Compiling a report of coho and lake trout diet information available for Lake Michigan from 1980 to 1995
- **$** Judging the representativeness of the diet data collected for the LMMB project
- **$** Identifying relationships between the top predator fish and their prey

Status: ongoing

Data Results: For lake trout, 12 sources of diet data have been identified, covering 5 geographic areas of Lake Michigan. The diet data include years 1982-1988, 1985-1986, 1991-1994, and 1994-1995. The data are being summarized.

For coho salmon, three additional data sets were identified, covering both western and eastern nearshore areas. The data include years 1982-1988, 1985-1986, and 1991-1994. The data are being summarized.

Environmental Results/Products: Results of this study will help determine how representative the diet data collected during 1994-1995 are compared to historical feeding behavior. This information will thereby provide the means to assess the reliability of the LMMB model for predicting outcomes of various environmental management scenarios.

Spatial and Temporal Variation of Plankton Communities In Lake Michigan: A Multi-Variate Approach(FY 1997-GL985551)
The Research Foundation of State University of New York

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Award Amount: FY 1997-$54,959

Dollars Leveraged: $2,890

Project Timetable: September 1997-January 1999

GLNPO Project Officer: Marc Tuchman (312)886-0239

Narrative: Phytoplankton and zooplankton communities can be used as indicators of environmental conditions in the Great Lakes. The Lake Michigan ecosystem has undergone much change over the past 100 years as a result of physical, chemical, and biological perturbations. Most recently the introduction of non-indigenous species has significantly modified the Lake Michigan food web. The purpose of the project is to conduct a multi-variate statistical analysis of the Lake Michigan data set collected at 15 stations in 1994-1995. The data set includes phytoplankton and zooplankton abundance, biovolume and species composition information, as well as physio-chemical information. The project will help explain how the lake=s system functions by identifying key links between biology, chemistry , and physical properties. The results will improve our ability to identify changes to the Lake Michigan ecosystem and understand the factors that drive them.

Project **objectives** include:

- **$** Assessing temporal(season, year) and spatial(sampling stations) variation in plankton biomass and community diversity
- **$** Identifying, summarizing and interpreting the environmental conditions among the 15 sampling stations in Lake Michigan
- **$** Evaluating if groups of species vary in a spatially distinct manner, and if so, to explore possible explanations for this based on the autecology of the indicator organisms present

Status: ongoing

Data Results: Collaboration has begun with personnel at the EPA and EPA contractors at Grace Laboratories to analyze a dataset collected by the US EPA over a 2-year period as part of the

LMMB study. The dataset consists of physical, chemical, and biological parameters measured on 7 lake-wide cruises form 1994-95. Measurements were made at 23 stations throughout the lake.

Environmental Results/Products: The results from multivariate analyses indicated that abundance of phytoplankton species varies along and environmental gradient of Si:P. The occurrence of individual species along the gradient coincides with predictions from nutrient competition theory. Moreover, the timing of species seasonal succession patterns varies with latitude, such that seasonal changes progress more swiftly in southern versus northern regions of Lake Michigan.

Additional Sources:

Published Abstract and Oral Presentation-
Barbiero, R.P., H.J. Carrick, J.B. Volerman, and M.L. Tuchman, 1998. Spatial and temporal heterogeneity in the phytoplankton communities of Lake Michigan, USA. XXVII Congress, Society of International Limnology.

Journal Article-
Barbiero, R.P., H.J. Carrick, J.B. Volerman, and M.L. Tuchman, 1998. A multivariate study of factors determining the phytoplankton community composition in Lake Michigan, with special reference to diatoms. *International Revue of Hydrobiologie*, In press.

Atmospheric Loading of Total Mercury to Lake Michigan (FY 1997-GL985725)
University of Michigan

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Award Amount: $171,700

Dollars Leveraged: $15,489

Project Timetable: October 1,1997-March 29,1999

GLNPO Project Officer: Angela Bandemehr (312)886-6858

Narrative: This agreement will enable the University of Michigan to calculate the atmospheric loadings of mercury to Lake Michigan. This project supplements work done under another project entitled AAtmospheric Loading of Toxic Contaminants to Lake Michigan@(GL985430), which is funded with Great Waters monies.

Project **objectives** include:

- **$** Determining the portion of the atmospheric deposition loading of total mercury to Lake Michigan due to Awet deposition@
- **$** Determining the portion of the atmospheric deposition loading of total mercury to Lake Michigan due to Adry deposition@
- **$** Developing methods for the determination of dry deposition velocities and volatilization rates for mercury
- **$** Developing methods for the determination of the vapor-phase concentrations for mercury in the air-water interface

Status: ongoing

Data Results: Using data from four land-based sites around Lake Michigan, loadings of total mercury to lake Michigan are being calculated.

Environmental Results/Products: Loadings of mercury will be supplied to modelers at GLERL/EPA for input into the Lake Michigan model.

Lake Trout Movements to the Sturgeon Bay Biota Box (FY 1997-DW14947826)
U.S. Fish and Wildlife Service

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mark_holey@mail.fws.gov

Award Amount: $26,472

Dollars Leveraged: $33,560

Project Timetable: August 1,1997-January 31, 2000

GLNPO Project Officer: Paul Bertram (312)353-0153

Narrative: The Lake Michigan Mass Balance (LMMB) project was designed to measure and quantify contaminants in three areas of Lake Michigan: the northern near-shore area off Sturgeon Bay, the mid-lake reef complex, and the southern near-shore area off Sagatuck. The LMMB project and model assumes that the pathway by which contaminants accumulate in the lake trout sampled in a given area is through prey eaten within that area. If the contaminant mass in the lake trout sampled in an area was obtained from prey in another region of the lake, because of trout movement, then the diet sampled may not be a good representation of the food web-contaminant dynamics within that area. This project will seek to describe the home range and movement of lake trout in the Sturgeon Bay area to verify if the contaminant burden of lake trout sampled in that area was obtained from the food web present there.

Project **objectives** include:

- **$** Compiling and interpreting lake trout tag recovery data for movements, distribution and home range
- **$** Mapping the tag recoveries around Lake Michigan using GIS, standardized to the number of lake trout caught in angling, commercial and assessment fisheries.
- **$** Examining the temporal distribution of tag recoveries to determine if lake trout return to the Sturgeon Bay area

Status: ongoing

Environmental Results/Products: The products of this study will include: 1)a description of the home range of the lake trout in the Sturgeon Bay area, which can be used to determine if lake trout move in and out of the Sturgeon Bay study area; 2) the distribution and relative abundance of the tagged lake trout; and 3) the relationship between movements and population density.

Atmospheric Loading of PCBs, Trans-nonachlor, Atrazine, Nitrogen and Phosphorus to Lake Michigan Waters (FY 1997-GL985727)
***Research Foundation of State University of New York* (SUNY)**

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Award Amount: $43,299

Dollars Leveraged: $2,704

Project Timetable: October 1,1997-September 30,1999

GLNPO Project Officer: Angela Bandemehr (312)886-6858

Narrative: The relative importance of chemical inputs to the lake, especially atmospheric inputs, is poorly understood for nearly all chemicals. This poses a critical problem because atmospheric inputs exert a very strong influence in our ability to predict chemical behavior. This agreement will allow SUNY Buffalo to estimate atmospheric loadings of PCBs, Atrazine and trans-Nonachlor in support of the Lake Michigan Loading Study/Mass Balance (LMMB). This project runs parallel with the project entitled AAtmospheric Loadings of PCBs, t-Nonachlor and Atrazine, Nitrogen and Phosphorous to Lake Michigan@.

Project **objectives** include:

- **$** Summarizing the current knowledge of atmospheric depositional processes and loadings of the target chemicals to Lake Michigan
- **$** Reviewing the data available form the LMMB with respect to quality control; suitability for loading estimates and comparability with other available data.
- **$** Estimating atmospheric deposition and loadings of the target compounds to Lake Michigan with respect to spatial variability and temporal variability
- **$** Calculating the uncertainty associated with the atmospheric deposition and loading estimates for the target compounds
- **$** Providing the loading estimates in a format accessible and useful to the whole lake

mass balance modeling effort

Status: ongoing-extended for one year to Sept. 30, 1998

Data Results: Initial estimates of loadings of PCBs, trans-nonachlor, atrazine, N&P have been made. The loadings estimates are being refined based on improved algorithms and discussion with EPA modelers. Results have been presented at a variety of conferences including the International Association of Great Lakes Research conference(1997&1998). Loadings vary extensively both spatially and temporally depending on wind speed, wind direction, and air temperature, and proximity of sources.

Environmental Results/Products: The final results of this project will be delivered to the EPA LMMB modelers and will be wet deposition, dry deposition, and vapor phase concentration of target contaminants at the air-water interface.

Additional Sources:

Miller, S.M.; Green, M.L.; DePinto, J.V. and Hornbuckle, K.C., October, 1997. The Influence of Sampling Site Location on Air-Water Exchange of Semivolatile Organic Compounds. Midwest Environmental Chemistry Workshop. Bloomington, IN.

Green, M.L.; DePinto, J.V. Green, M.L. and Hornbuckle, K.C., October, 1997. Large Scale Atmospheric Effects on Great Lakes Basin Contaminants. Midwest Environmental Chemistry Workshop. Bloomington, IN.

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Green, M.L.; DePinto, J.V. Hornbuckle, K.C. and Miller, S.M,. May, 1998. Temporal and Spatial Interpolation of Atmospheric Gas Phase PCB Measurements during the Lake Michigan Mass Balance Study. Annual Meeting of the International Association for Great Lakes Research (IAGLR). Hamilton, Ontario.

Miller, S.M.; Green, M.L.; DePinto, J.V. and Hornbuckle, K.C., May, 1998. An Investigation of Over-Water Sampling: a Case Study. Annual Meeting of the International Association for Great Lakes Research (IAGLR). Hamilton, Ontario.